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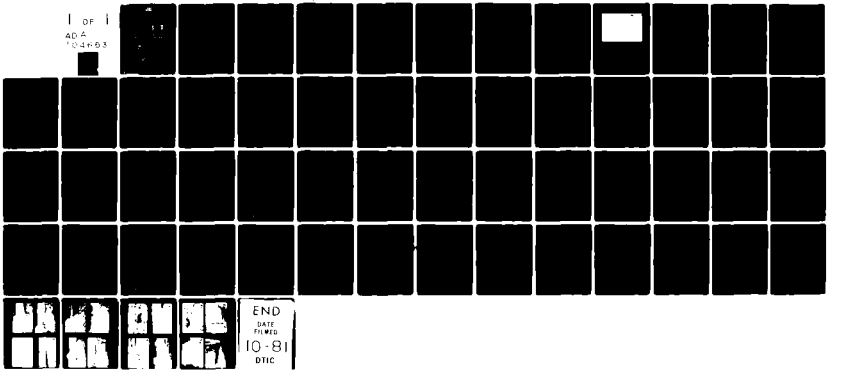

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LEVEL II

OSAGE-GASCONADE RIVER BASIN

AD A104663

HARDECKE LAKE DAM

GREENE COUNTY, MISSOURI

MO 30148

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST, 1980

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Phase 1 Inspection Report for Hardecke Lake Dam (MO 30148)

This report presents the results of field inspection and evaluation of the Hardecke Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. The combined capacity of the spillways will not pass 50 percent of the Probable Maximum Flood and is marginal to pass the 10-year flood without overtopping the dam.

b. Overtopping of the dam could result in failure.

c. Dam failure significantly increases the hazard to life and property downstream.

The owner should initiate immediate action to increase the spillway capacity. The existing emergency spillway does not presently provide any useful overflow capacity because its' crest elevation is equal to the elevation of the top of the dam.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 11 FEB 1981 Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 11 FEB 1981 Date

OSAGE-GASCONADE RIVER BASIN

HARDECKE LAKE DAM
GREENE COUNTY, MISSOURI
MISSOURI INVENTORY NO. 30148

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

AUGUST, 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

Name of Dam: Hardecke Lake Dam
State Located: Missouri
County Located: Greene
Stream: Tributary of Pomme De Terre River
Date of Inspection: July 17, 1980

Hardecke Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of this inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are four cabins and three large buildings. These buildings are a part of the complex of Happy Hollow (church camp) which are occupied during the summer months.

The dam is in the small size classification, since it is less than 40 ft high, and the maximum storage capacity is greater than 50 ac-ft but less than 1,000 ac-ft.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will pass 6 percent of the Probable Maximum Flood without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the height of dam (22 feet) and the maximum storage capacity (103 acre-feet),

50 percent of the PMF has been determined to be the appropriate spillway design flood. The 10-year flood (10 percent probability flood) will overtop the dam. The 10 percent probability flood is one that has a 10 percent chance of being exceeded in any given year.

The embankment appeared to be in good condition. Deficiencies visually observed by the inspection team were: (1) upstream and downstream slopes lined with trees and brush; (2) reported seep area in vicinity of pipe valves; (3) small trees and brush in spillway outlet channel; (4) no elevation difference between top of dam and emergency spillway; and (4) lack of trash protection screen for spillway.

Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.

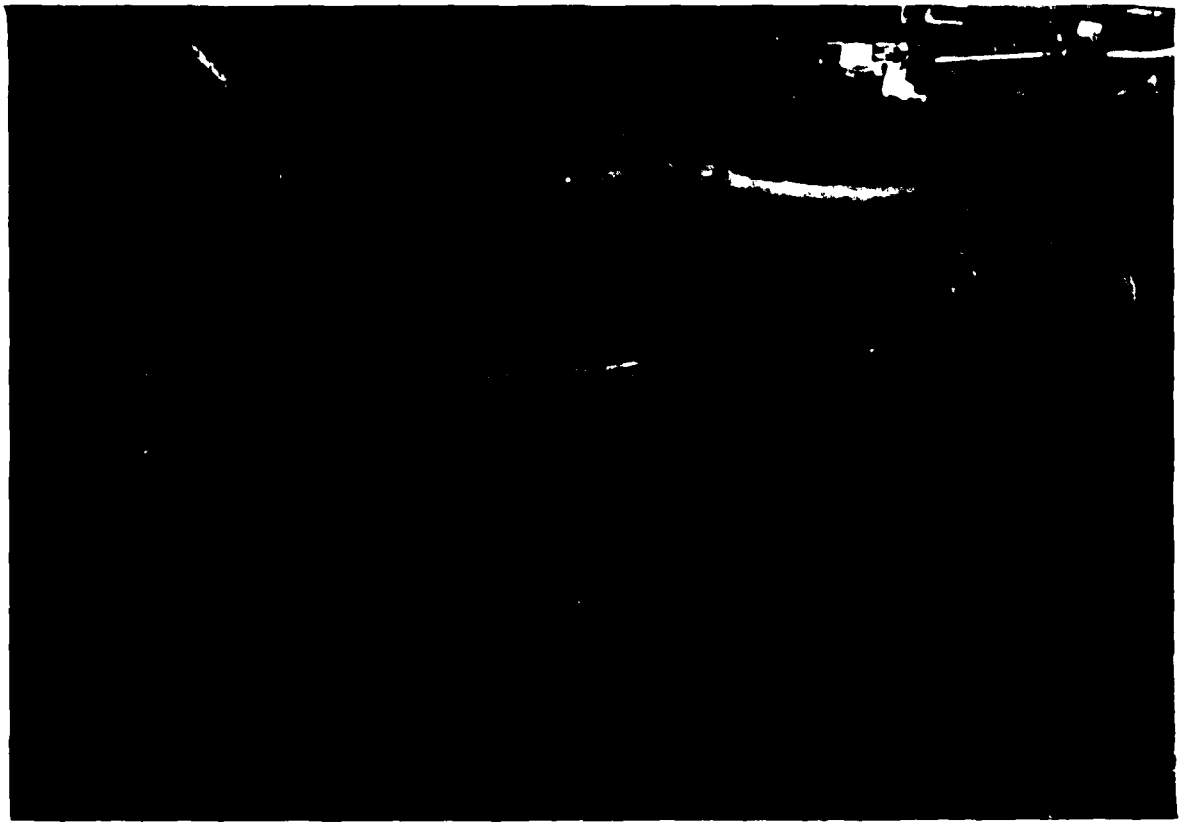
Steven L. Brady, P.E.
Anderson Engineering, Inc.

Tom Beckley, P.E.
Anderson Engineering, Inc.

Jack Healy, P.E.
Hanson Engineers, Inc.

Gene Wertepny, P.E.
Hanson Engineers, Inc.

Brad Parrish, E.I.T.
Anderson Engineering, Inc.



AERIAL VIEW OF LAKE AND DAM

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HARDECKE LAKE DAM
MISSOURI INVENTORY NO. 30148

TABLE OF CONTENTS

APPENDICES

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Hardecke Lake Dam in Greene County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Hardecke Lake Dam is an earth fill structure approximately 22 ft high and 630 ft long at the crest. The appurtenant works consist of a four inch cast iron pipe through the embankment with a four inch and a two and one-half inch valve and an earth cut swale in the west abutment.

Sheet 3 of Appendix A shows a plan, profile, and typical section of the embankments.

B. Location:

The dam is located in the northwestern part of Greene County, Missouri on a tributary of Pomme De Terre. The dam and lake are within the Strafford, Missouri 7.5 minute quadrangle sheet (Section 11, T30N, R20W - latitude 37°19.7'; longitude 93°06.2'). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 22 ft and a maximum storage capacity of approximately 103 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a potential high hazard dam. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are four cabins and three large buildings. These buildings are part of the complex of Happy Hollow (church camp). A photograph of the cabins is included in Appendix D (Photo No. 16). These cabins and buildings are occupied during the summer months.

E. Ownership:

The dam is owned by Mr. Carl Hardecke, Jr. The owner's address is Route 3, Box 177, Strafford, Missouri (telephone number 417/736-3144).

F. Purpose of Dam:

The dam was constructed primarily for livestock watering and fishing.

G. Design and Construction History:

The dam was constructed in 1964 by Mr. George Reed, the owner of the property at the time. No design calculations were made for the construction of the dam.

Mr. Reed stated that a core trench about 12 feet wide was excavated to rock. The average depth of the trench was estimated to be 8 feet. The material for construction of the dam was obtained from the lake bed area. A four inch cast iron pipe was installed in the embankment with two valves at the outlet end. The four inch valve was used to lower the lake level and the two and one-half inch valve was to be used for irrigation. Mr. Reed reported that he used the four inch valve numerous times to lower the lake level a couple of feet. He had never used the irrigation valve.

The flow line of the spillway channel was constructed approximately four to five feet below the crest of the embankment. According to Mr. Reed, the lake level was almost continuously at normal pool level with the spillway channel being used many times each year. He stated that to his knowledge, the dam had never been overtopped.

The current owner of the dam, Mr. Hardecke, acquired the dam in 1975. At that time there was considerable erosion in the spillway channel. The spillway channel was filled in with material from the adjacent hillside. Boulders and broken pieces of concrete slab were placed in the erosioned areas of the downstream spillway channel. At the same time the 10 and 12 inch clay tile pipe was installed in the spillway channel at centerline of dam. The owner reported that the spillway flow line was raised by a couple of feet. The current owner also indicated that the dam had never been overtopped. He stated that the water level was within a foot of the top of dam.

H. Normal Operating Procedures:

The normal flows are discharged through the uncontrolled tile pipes (10 and 12 inch) with excess flows through the spillway section at the same location. The lake level can be lowered by use of the four inch pipe through the embankment. The spillway reportedly operates only after heavy rainfalls.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 3 of Appendix A presents a plan, profile, and typical section of the embankment.

A. Drainage Area:

The drainage area for this dam, as obtained from the U.S.G.S. quad sheet, is approximately 184 acres.

B. Discharge at Dam Site:

(1) All discharge at the dam site is through uncontrolled spillways.

(2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 1,259.8): 8 cfs

(3) Estimated Capacity of Principal Spillway: 8 cfs (Elev 1,259.8)

(4) Estimated Capacity of Emergency Spillway: 0 cfs (Elev 1,259.8)

(5) Estimated Experience Maximum Flood at Dam Site: Unknown

(6) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable

(7) Diversion Tunnel Outlet at Pool Elevation: Not Applicable

(8) Gated Spillway Capacity at Pool Elevation: Not Applicable

(9) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level elevation of 1,260 for crest of dam (estimated from quadrangle map).

(1) Top of Dam: 1,259.8 feet, MSL (low point of crest)

(2) Principal Spillway Crest: 1,258.0 feet, MSL

(3) Emergency Spillway Crest: 1,259.8 feet, MSL

(4) Principal Outlet Pipe Invert: Not Applicable

(5) Streambed at Centerline of Dam: 1,238.0 feet, MSL

(6) Pool on Date of Inspection: 1,246.2 feet, MSL

(7) Apparent High Water Mark: 1,259.0 feet, MSL

(8) Maximum Tailwater: Not Applicable

(9) Upstream Portal Invert Diversion Tunnel: Not Applicable

(10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

(1) At Top of Dam: 1,100 feet

(2) At Emergency Spillway Crest: 1,100 feet

(3) At Principal Spillway Crest: 1,000 feet

E. Storage Capacities:

(1) At Top of Dam: 103 acre-feet

(2) At Emergency Spillway Crest: 103 acre-feet

(3) At Principal Spillway Crest: 81 acre-feet

F. Reservoir Surface Areas:

(1) At Top of Dam: 12.8 acres

(2) At Emergency Spillway Crest: 12.8 acres

(3) At Principal Spillway Crest: 11.0 acres

G. Dam:

(1) Type: Rolled Earth

(2) Length at Crest: 630 feet

(3) Height: 22 feet

(4) Top Width: 14 feet

(5) Side Slopes: Upstream varies from 1V on 1.6H to 1V on 2.7H; Downstream 1V on 1.7H

(6) Zoning: Apparently Homogeneous

(7) Impervious Core: Clay Core 12 feet wide at base

(8) Cutoff: Key trench 8 to 10 feet deep to solid rock

(9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

(1) Type: Not Applicable

(2) Length: Not Applicable

(3) Closure: Not Applicable

(4) Access: Not Applicable

(5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Principal Spillway:

(1) Location: West Abutment

(2) Type: 10 and 12 inch Diameter Clay Tile Pipe

I.2 Emergency Spillway:

(1) Location: West Abutment

(2) Type: Earth Cut Swale and Embankment Fill over the Tile Pipe.

(3) Upstream Channel: Grass-covered Earth Channel

(4) Downstream Channel: Tree-lined Earth Cut Channel with Mild Side Slopes

J. Regulating Outlets:

The level of the lake can be varied by use of the four inch pipe through the embankment. Two valves are located at the outlet end.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

No engineering data exists for this dam. To our knowledge no construction inspection records or documented maintenance and operation data exist.

A. Surveys:

No information regarding pre-construction surveys was able to be obtained. Sheet 3 of Appendix A presents a plan, profile, and cross section of the dam and Sheet 3A of Appendix A presents a profile and section of the spillway. The top of a rock at Station 4 + 50 was used as a reference point to determine all other elevations. It is estimated that this site datum approximately corresponds to mean sea level elevation 1260.0

B. Geology and Subsurface Materials:

The topography around the site is gently rolling to hilly. This area is at the eastern edge of the Western Plains region of the state. Generally, the soils around the dam consist of deep, well drained, cherty, silty, clay soils. Those soils are residual from cherty Mississippian limestones. Typically, these soils have a brown, cherty, clayey silt surface layer followed by a reddish-brown, friable silty clay containing considerable chert rock fragments. The lower horizon is a red, dark red, crumbly, plastic, silty clay which has varying amounts of chert rock. Weathered ledge rock is often found near the surface in this area. The underlying rock is of the Burlington formation of the Osagean Series of the Mississippian Systems. The Burlington formation is a white to light buff, very coarsely crystalline, fossiliferous, crinoidal limestone. Layers of chert nodules are common in the upper portions of this formation. The bedrock has often weathered unevenly leaving pinnacles, mushroom-like knobs projecting from the rock surface. The crevices between these knobs are filled with the red, often highly plastic, silty clay.

Geologic mapping of Greene County, Missouri compiled by Kenneth C. Thomson of Southwest Missouri State University, shows one fault zone near the site. The Strafford fault lies approximately 2 miles south of the dam site. The Department of Natural Resources has indicated that the faults in this area are generally considered to be inactive and have been for several hundred million years (rock associated with the Mississippian period is approximately 300 million years old). Additional mapping by Mr. Thomson indicates the nearest area of sinkhole features is approximately 4 miles southeast of the dam site. The nearest cave is approximately 4 miles west of the dam site.

C. Foundation and Embankment Design:

No foundation and embankment design information was available. Seepage and stability analyses apparently were not performed as required in the guidelines. No construction inspection test results have been obtained. No internal drainage features are known to exist.

D. Hydrology and Hydraulics:

No hydrologic or hydraulic design computations for this dam were available. Based on a field check of spillway dimensions, embankment elevations, and a check of the drainage areas on U.S.G.S. quad sheets, hydrologic analyses using U. S. Army Corps of Engineers guidelines were performed and appear in Appendix C, Sheet 1 through 9.

E. Structure:

There are no structures associated with this dam.

2.2 CONSTRUCTION:

No construction inspection data were available.

2.3 OPERATION:

Normal flows are passed by the uncontrolled, tile pipes at the West Abutment. Excess flows would be carried by the channel section at the same location. The elevation of the channel section is the same as the low point of the dam. Consequently the excess flows passing through the channel section would also overtop the dam embankment. The four inch pipe, with valves, through the embankment can be used to regulate the level of the lake.

2.4 EVALUATION:

A. Availability:

No engineering data, seepage or stability analyses, or construction test data were available.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

To our knowledge, no valid engineering data on the design or construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on July 17, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steven L. Brady, P.E. - Anderson Enginering, Inc. (Civil Engineer)
Tom Beckley, P.E. - Anderson Engineering, Inc. (Civil Engineer)
Jack Healy, P.E. - Hanson Engineers, Inc. (Geotechnical Engineer)
Gene Wertepny, P.E. - Hanson Engineers, Inc. (Hydraulic Engineer)
Brad Parrish, E.I.T. - Anderson Engineering, Inc. (Geotechnical Engr.)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam appeared to be in good condition. The upstream and downstream slopes had considerable tree and brush growth. No sloughing or other unusual movement of the embankment was noted. No animal burrows were observed.

The vertical alignment of the crest appeared good. An apparent sag of the vertical alignment was observed near Station 2 + 00. The elevation at this point was approximately the same as the elevation of the spillway channel at the west abutment. The horizontal alignment was good.

The upstream slope of the embankment has a good covering of riprap extending the length of the embankment, at normal pool level. Some of the riprap has been dislodged and moved down the slope. No noticeable erosion of the slope was noted.

The owner reported that an apparent seep area exists at the downstream toe of the embankment near the center of the dam, between Station 3 + 00 and 4 + 00, and near the west abutment. He stated that the marshy area is noticeable when the lake level is at or near normal pool level. Due to the low pool level on the date of inspection, no seeps or marshy areas were observed.

The valves at the outlet end of the four inch drawdown pipe appeared to be in working condition. The owner reported that he has not used the valves since owning the dam.

Shallow auger probes into the embankment indicated the dam to consist of a brown silty clay with some chert fragments (CL). The owner indicated that the material for the embankment was obtained from the lake bed.

No instrumentation (monuments, piezometers, etc.) was observed.

C. Appurtenant Structures:

C.1 Principal Spillway:

The approach area to the 10 and 12 inch clay tile pipe was clear. No obstructions of the pipes were observed. The pipes were installed in 1976. No provision for trash screens are made. The owner indicated that the spillway pipes rarely carry any flows.

C.2 Emergency Spillway:

The emergency spillway is a channel located at the west abutment, formed from a previously earthcut swale; now with an embankment fill over the primary spillway pipes. Mr. Reed, the builder of the dam, indicated that the emergency spillway was initially constructed about 4 feet lower than the top of dam. The flow line of the emergency spillway, top of fill over the pipes, is at the same elevation as the low point of the dam crest. Mr. Reed stated that the emergency spillway functioned many times each year while he owned the property. Immediately downstream, the channel is lined with boulders and broken pieces of concrete slab. Some small trees and brush were noted in the outlet channel.

D. Reservoir:

The watershed is generally pastureland and wooded area with mild side slopes. No sloughing or erosion of the reservoir slopes was observed. Considerable sedimentation was noted in the lake bed.

E. Downstream Channel:

The downstream channel is also pastureland and wooded. The channel is generally tree lined. The channel goes under a county road about one-half mile downstream of the dam. The slopes are generally mild from the dam to the county road, at which point the slopes are moderate to steep.

3.2 EVALUATION:

The dam is in good condition. The tree and brush growth on the embankment can provide shelter for small animals and encourage burrowing. The riprap along the upstream slope appears to be in good condition with no noticeabe erosion. The tree and brush growth could adversely affect the embankment stability. The reported seep areas could, if normal pool level is maintained, seriously affect the stability of the dam. The emergency spillway does not provide any usage due to the equal elevation with the low point of the dam crest.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The operating facilities for this dam are the four inch diameter pipe, with two valves. The four inch valve is used to lower the pool level, if desired. The two and one-half inch valve was installed to provide for irrigation of downstream fields. The valves have not been operated for a number of years. Hence, the pool is normally controled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillway, and the reported seepage from the reservoir.

4.2 MAINTENANCE OF DAM:

The owner of the dam does not have any maintenance program. Maintenance of the dam is accomplished on an as needed basis by the owner.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The valves are apparently not maintained.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The tree and brush growth on the embankment and in the spillway channel, the reported seepage areas, lack of trash screen for spillway, and the non-functioning of the emergency spillway are serious deficiences which should be corrected. However, to avoid creating an unsafe condition, these deficiencies should be corrected under the direction of an engineer experienced in the design and construction of dams.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

No hydrologic or hydraulic design computations for this dam were available.

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owners reported that the dam has never been overtopped. Prior to raising the spillway elevation, the spillway functioned frequently. The owner states that the spillway rarely carries flow now. The reported high water behind the dam was about one foot below the embankment crest.

C. Visual Observations:

The approach area to the spillway is clear. The channel downstream of the spillway is lined with boulders and concrete debris. The use of the spillway channel is severely limited due to the flow line of the channel being at the same elevation as the low point of the dam.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U. S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) an estimate of the reservoir storage and the pool and drainage areas from the Strafford, Missouri 7.5 minute U.S.G.S. quad sheet.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the spillway will pass 6 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the height of dam (22 feet) and the maximum storage capacity (103 acre-feet), 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillway will not pass a 10 percent probability flood without overtopping the dam.

Application of the probable maximum precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 4,092 cfs. For 50 percent of the PMF, the peak inflow was 2,046 cfs.

The routing of the PMF through the spillway and dam indicates that the dam will be overtopped by 1.8 ft at elevation 1,261.6. The duration of the overtopping will be 16.4 hours, and the maximum outflow will be 3,668 cfs. The maximum discharge capacity of the spillway, at elevation 1,259.8, is 8 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.2 ft at elevation 1,261.0. The maximum outflow will be 1,755 cfs, and the duration of overtopping will be 14.1 hours. The routing of the 1 percent probability flood indicates that the dam will be overtopped by 0.5 ft at elevation 1,260.3. The maximum outflow will be 245 cfs, and the duration of overtopping will be 12.8 hours. The routing of the 10 percent probability flood indicates that the dam will be overtopped by 0.1 ft at elevation 1,259.9. The maximum outflow will be 23 cfs, and the duration of overtopping will be 10.8 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

No design and construction data were available for this dam. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The reported post-construction changes are the raising of the spillway section at the west abutment by about 3 feet, the installation of the 10 and 12 inch tile pipe, and the placement of the boulders and concrete in the downstream channel.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase 1 inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) brush and tree growth on the embankment; (2) small trees and brush in the spillway channel outlet; (3) the reported seepage areas at the downstream toe; (4) lack of trash screen provided for the spillway pipe inlets; and (5) the equal elevations of the crest of dam and the flow line of the emergency spillway.

Another deficiency was the lack of seepage and stability analyses records.

The dam will be overtopped by flows in excess of 6 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on the performance history as related by others, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The items recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

(1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the spillway should be protected to prevent erosion.

B. O & M Procedures:

(1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the design and construction of dams.

(2) The tree and brush growth should be removed from the embankent and the spillwy channel. The initial clearing should be done under the guidance of a professional engineer experienced in the design and construction of dams. Indiscriminate clearing methods could jeopardize the safety of the dam.

(3) The reported seepage areas along the downstream embankment toe should be investigated during periods of normal pool level, by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, these areas should be inspected periodically in an effort to detect any increase in the quantity of seepage or any indication that soil particles are being carried by the water. In this event, an experienced engineer should be contacted immediately.

(4) A trash screen should be provided for the inlet of the spillway pipes.

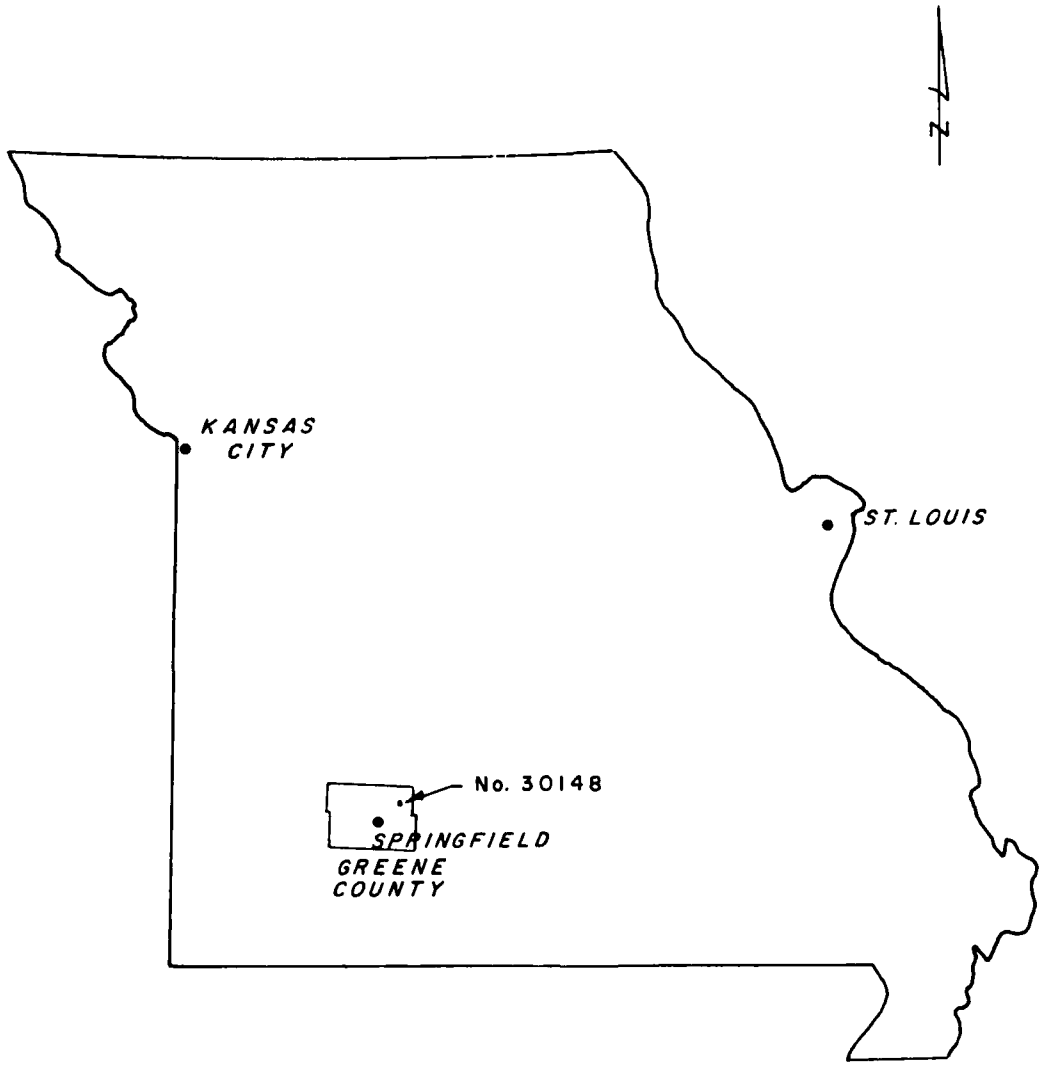
(5) An emergency spillway section should be provided. The crest of the dam should be raised or the flow line of the spillway channel lowered to provide an adequate flow section. The method and procedures should be done under the guidance of a professional engineer experienced in the design and construction of dams.

(6) The outlet valve of the drawdown pipe should be tested periodically to insure that the valve is operational.

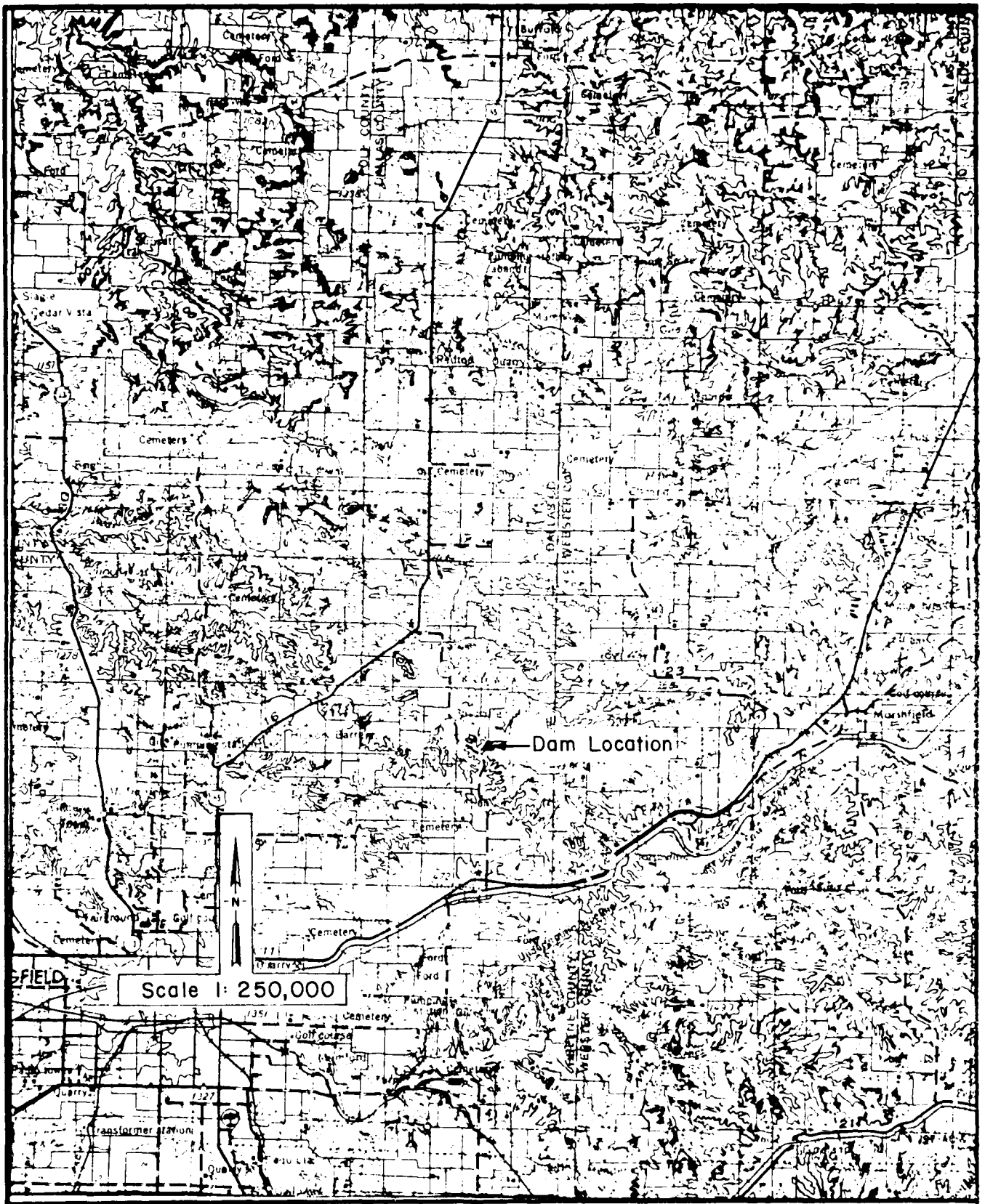
(7) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



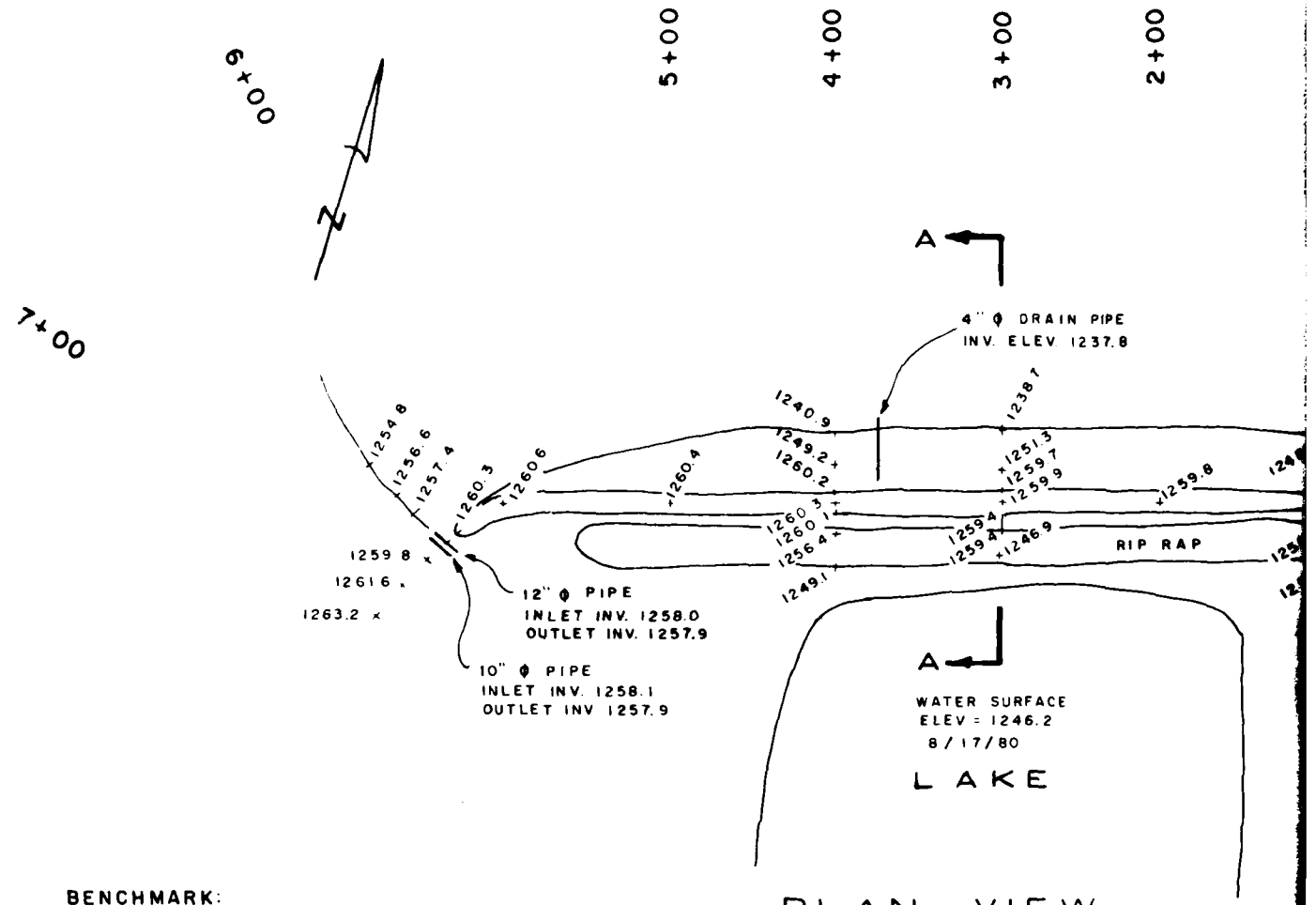
VICINITY MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

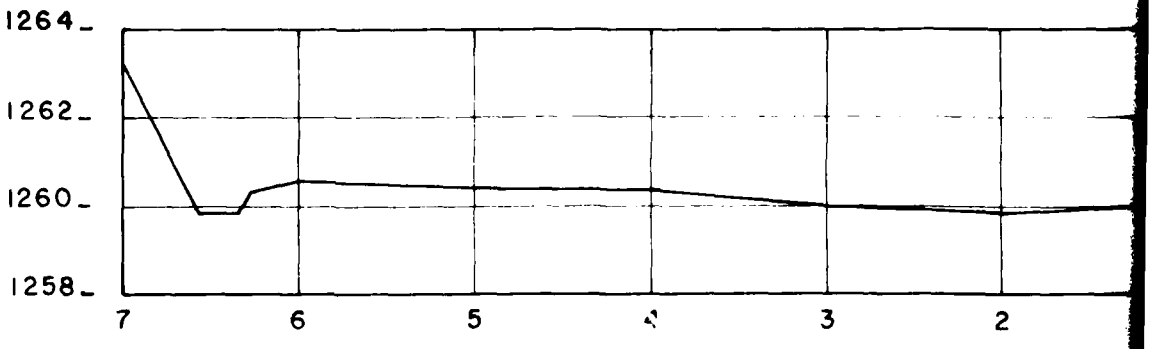
Hardecke Lake Dam
Greene County, Missouri
Mo I.D. No. 30148

Sheet 2, Appendix A



BENCHMARK:
ROCK AT STA 4+50 CENTERLINE OF DAM
ELEV. = 1260.0

PLAN VIEW
SCALE: 1" = 100'



PROFILE

3+00 2+00 1+00 0+00

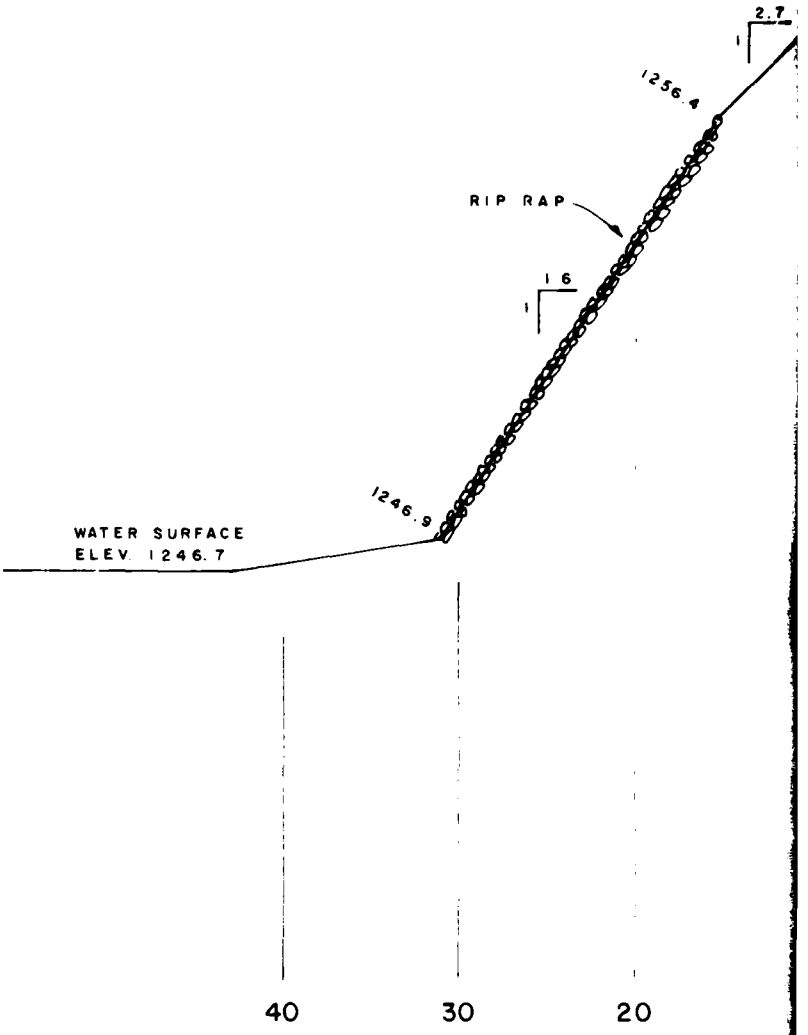
DRAIN PIPE
V. ELEV. 1237.8

1238.7
1251.3
1259.7
1259.9
1259.8
1248.2
1260.0
1259.9
1259.9
1260.6
1262.5
1246.9
RIP RAP
1258.3
1250.1

SURFACE
1246.2
/80

KE

VIEW
100'



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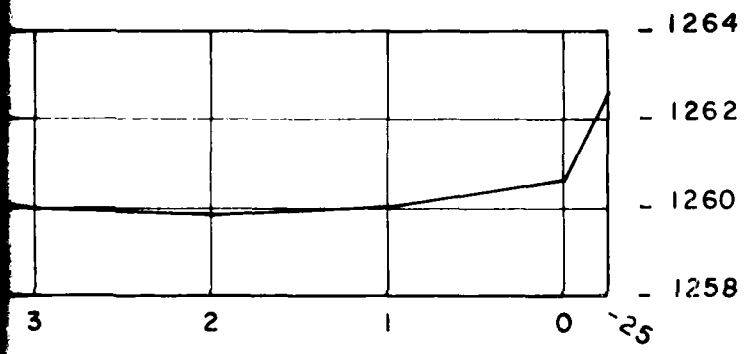

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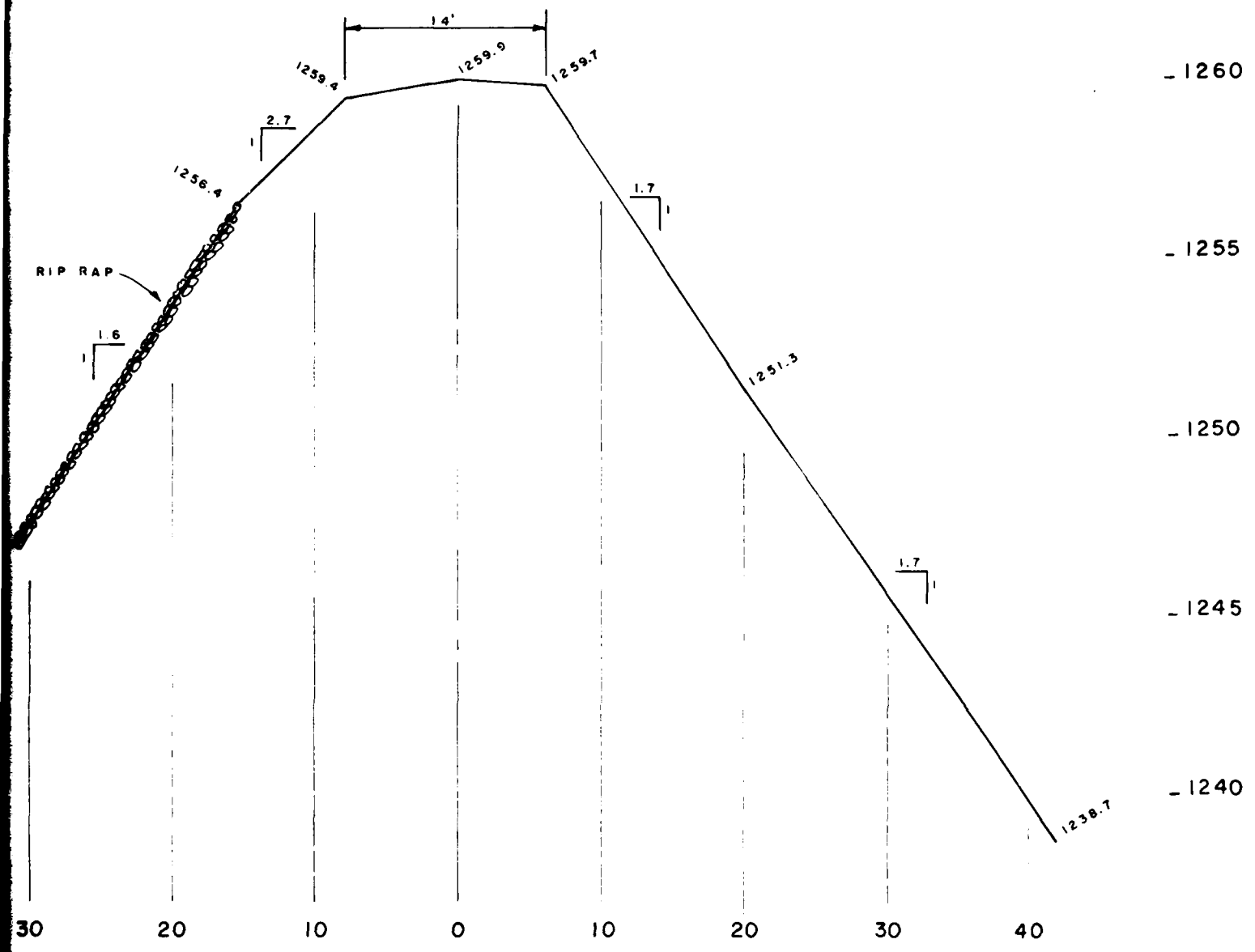
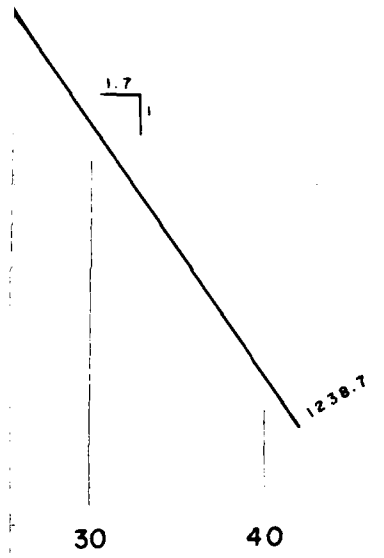


SECTION A-A STA 3+00



1260

1255

1250

1245

1240

30

40

SHEET 3 APPENDIX A

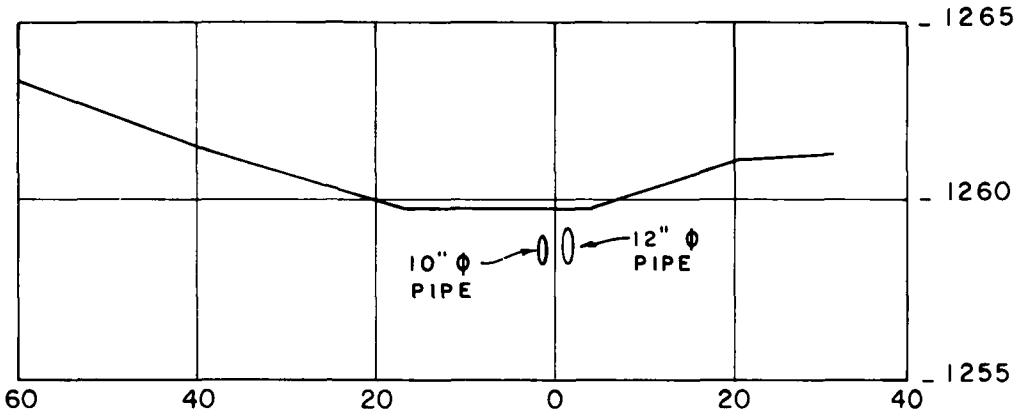
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

HARDECKE LAKE DAM

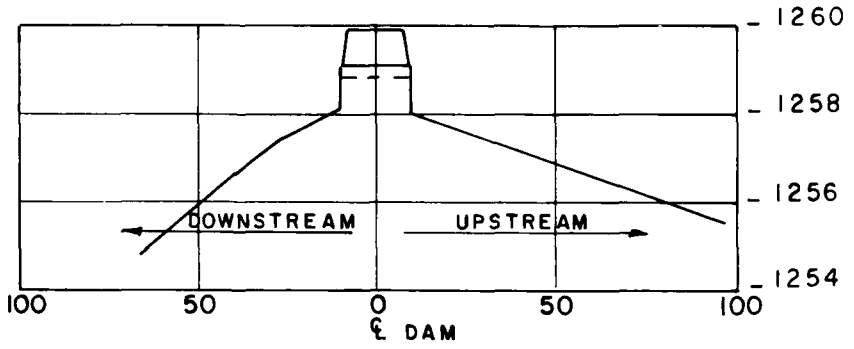
MO. No. 30148

PLAN & PROFILE

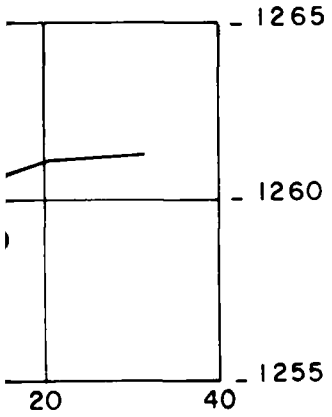
GREENE COUNTY, MO.



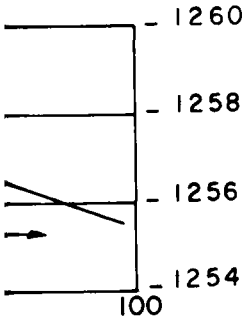
SPILLWAY SECTION ℄ DAM



SPILLWAY PROFILE



DAM



E

SHEET 3A APPENDIX A

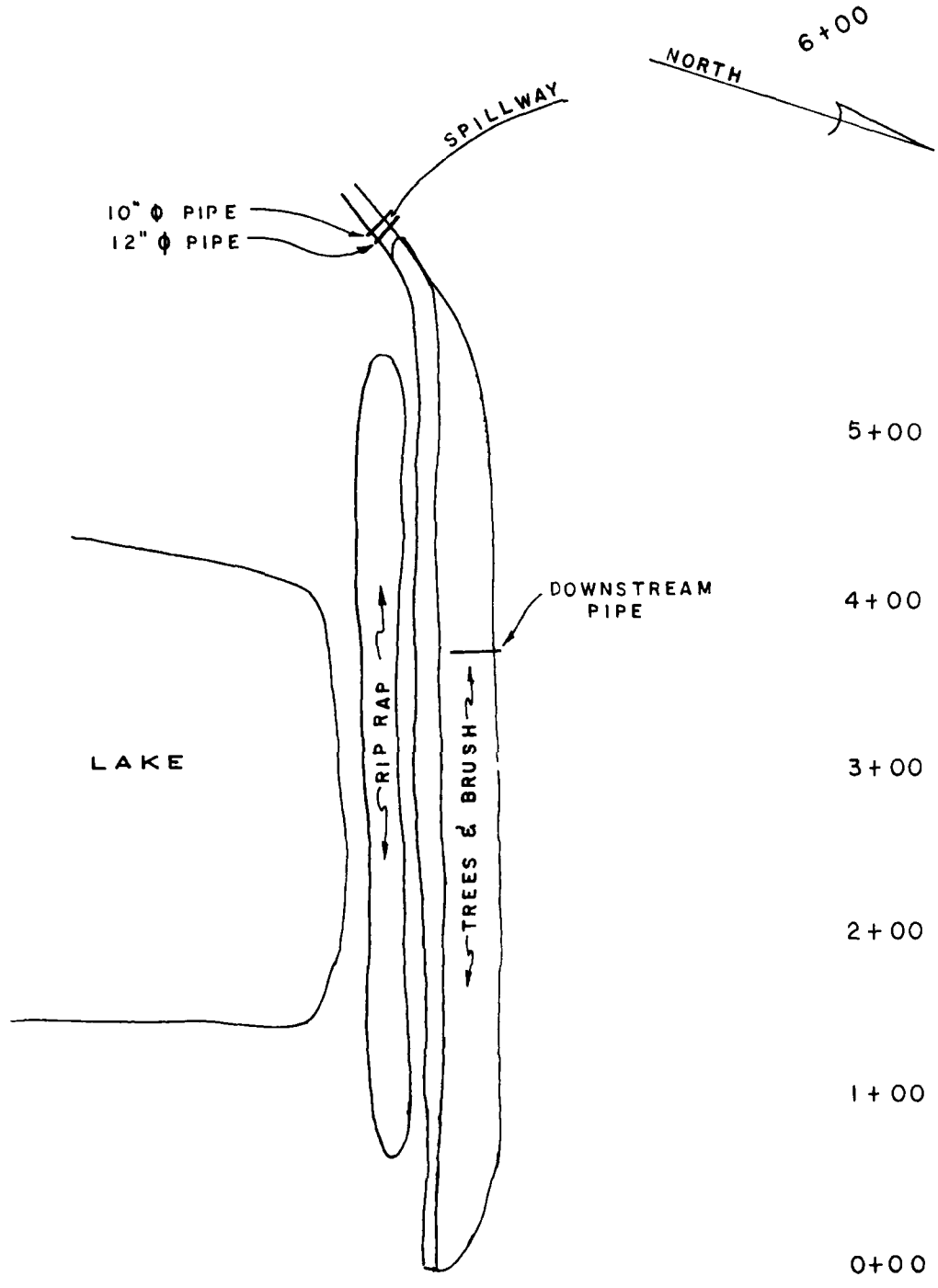
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

HARDECKE LAKE DAM

MO. No. 30148

SPILLWAY
SECTION & PROFILE

GREENE COUNTY, MO.



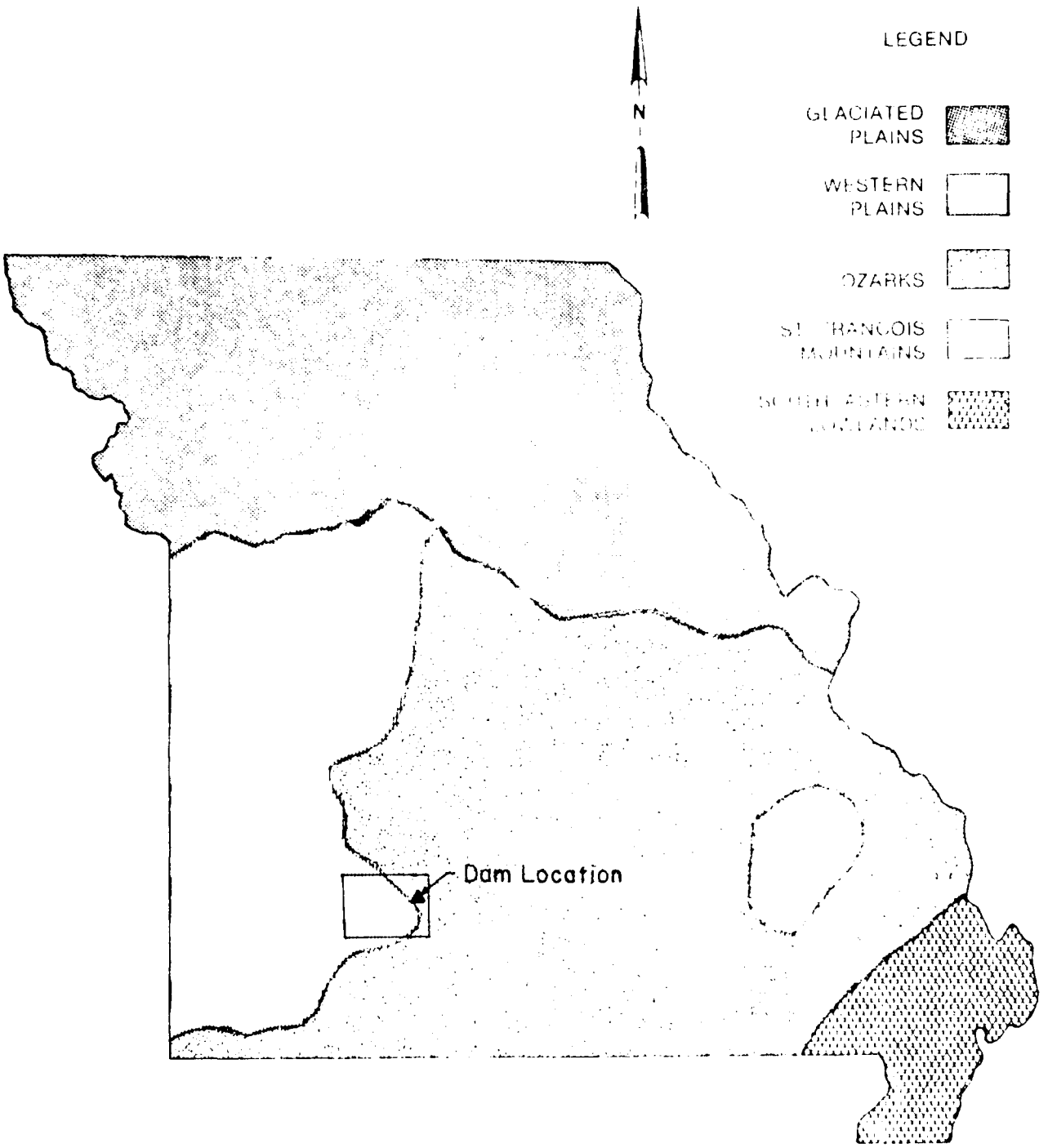
PLAN SKETCH OF DAM

HARDECKE LAKE DAM

MO. No. 30148

APPENDIX B

Geology and Soils



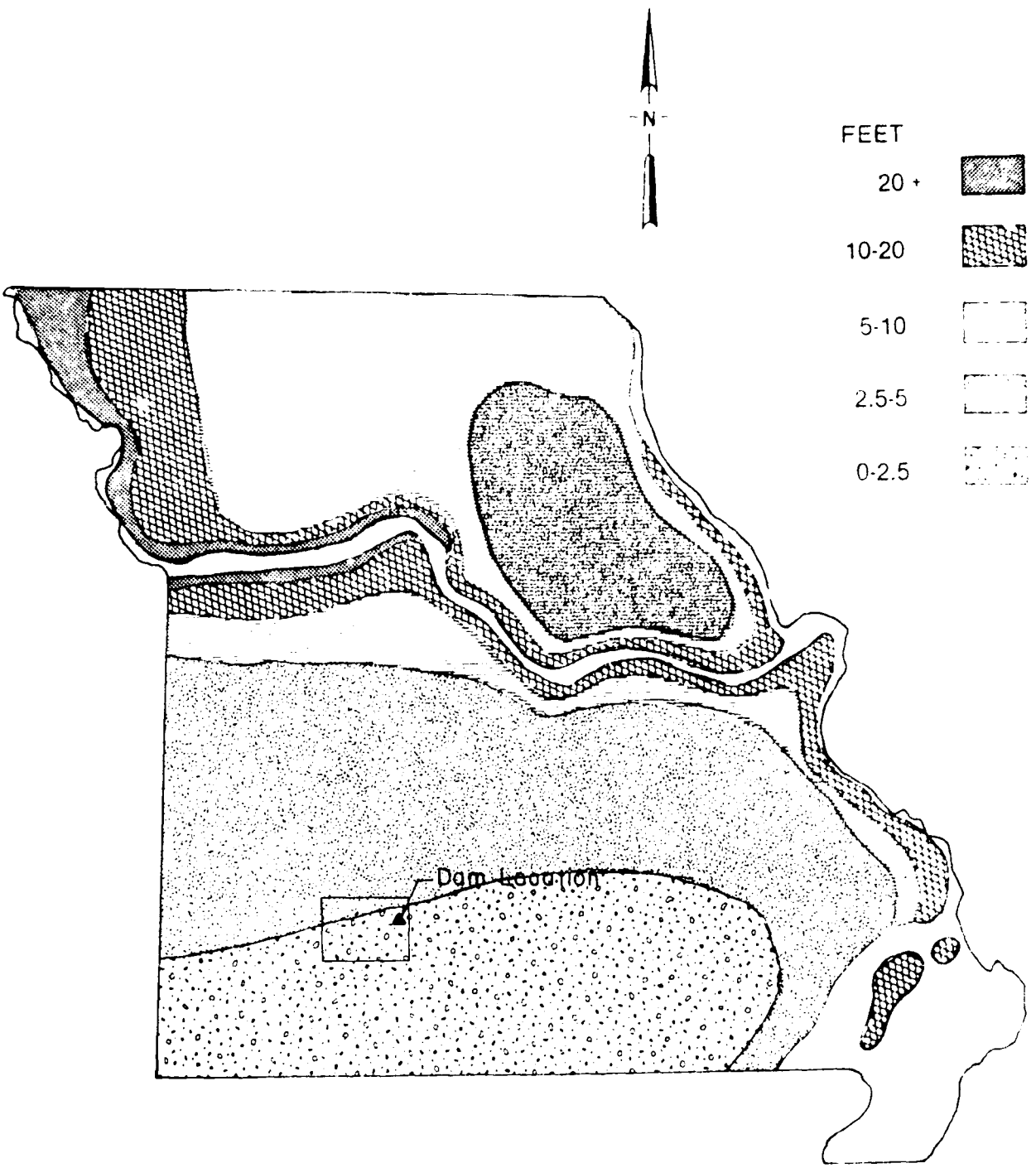
MAJOR GEOLOGIC REGIONS OF MISSOURI

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Hardecke Lake Dam
Greene County, Missouri
Mo. I.D. No. 30148

SHEET 1 APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS

HANSON ENGINEERS

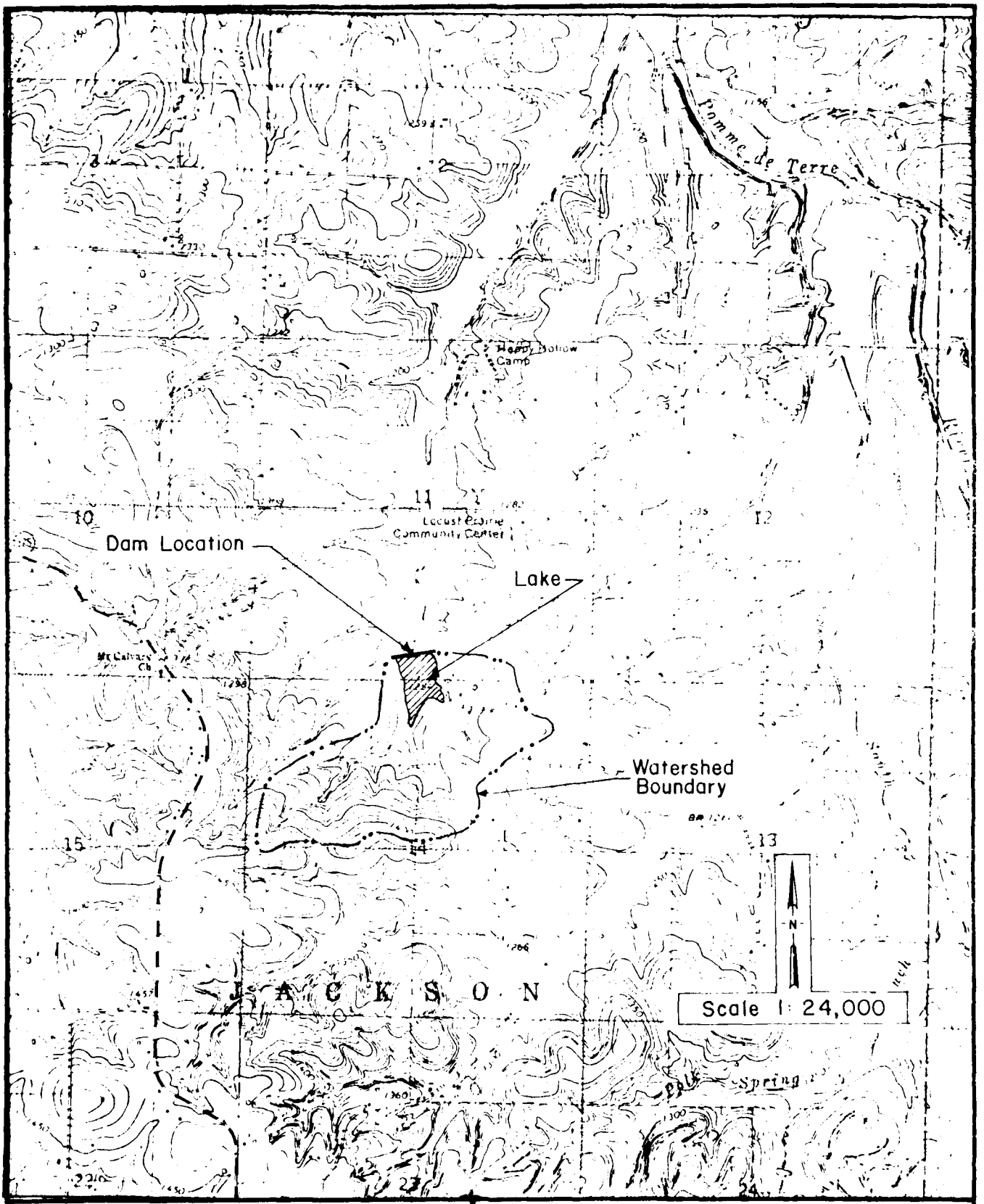
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Hardecke Lake Dam
Greene County, Missouri
Mo. I.D. No. 30148

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP

HANSON ENGINEERS

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Hardecke Lake Dam
Greene County, Missouri
Mo. I.D. No 30148

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (Dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent and the 10 percent chance probability flood was routed through the reservoir and spillway. Springfield rainfall distributions (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, were used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Pul Method. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C.)

The rating curve for the spillway (see Table 4, Sheet 5, Appendix C) was determined assuming entrance and pipe control for the principal spillway and critical flow condition at the control section for the emergency spillway.

The flow over the crest of the dam during overtopping was determined using the non-level dam option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8, and 9 of Appendix C.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	0.29 sq. miles
Length of Watercourse (L)	0.64 miles
Difference in elevation (H)	187 feet
Time of concentration (Tc)	0.21 hours
Lag Time (Lg)	0.13 hours
Time to peak (Tp)	0.17 hours
Peak Discharge (Qp)	826 cfs
Duration (D)	5 min.

Time (Min.)(*)	Discharge (cfs)(*)
0	0
5	367
10	819
15	594
20	254
25	116
30	53
35	24
40	11
45	5
50	1

(*) From the computer output

FORMULA USED:

$$Tc = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$ From California Culverts Practice, California Highways and Public Works, September, 1942.

$$Lg = 0.6\ Tc$$

$$Tp = \frac{D}{2} + Lg$$

$$Qp = \frac{484\ A.Q}{Tp}$$ Q = Excess Runoff = 1 inch

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	34.71	32.38	2.33
1 % Prob. Flood	24	7.99	4.18	3.82
10 $ Prob. Flood	24	5.64	2.34	3.30

Additional Data:

1) Soil Conservation Service Soil Group B
2) Soil Conservation Service Runoff Curve CN = 82 (AMC III) for the PMF
3) Soil Conservation Service Runoff Curve CN = 65 (AMC II) for the 1 percent chance flood
4) Percentage of Drainage Basin Impervious 7 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

Elevation (feet-MSL)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
1238.0	0	0	-
1254.0	8	43	-
*1258.0	11	81	0
**1259.8	12.8	103	8
1260.0	13	106	20
1270.0	24	291	-

*Principal spillway crest elevation
**Top of dam elevation

The above relationships were developed using the USGS Strafford, MO 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAYS RATING CURVE

Reservoir Elevation (MSL)	Principal Spillway (cfs)	Emergency Spillway (cfs)	Total Discharge (cfs)
1258.0	0	-	0
1259.0	4	-	4
*1259.8	8	0	8
1260.0	8	12	20
1260.5	9	48	57
1261.2	11	160	171
1262.0	13	287	300
1263.0	15	760	775
1264.0	17	1440	1457

* Top of dam elevation

METHOD USED:

1) Principal Spillway:

Charts for concrete pipes with entrance and full flow control, from the U.S. Bureau of Public Roads, were used.

2) Emergency Spillway:

Assuming critical flow condition at the control section.

FORMULA USED:

$$\frac{Q^2}{g} = \frac{A^3}{T}$$

Q = Discharge in cubic feet per second

A = Cross sectional area in square feet

T = Water surface width in feet

g = Acceleration of gravity in ft/sec^2

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	0	*1,258.0	81	0	-
0.05	205	1,259.7	102	8	-
0.06	246	**1,259.8	103	8	0
0.08	327	1,260.0	107	78	0.2
0.10	409	1,260.2	110	188	0.4
0.15	614	1,260.4	114	410	0.6
0.20	818	1,260.5	116	588	0.7
0.25	1,023	1,260.6	118	783	0.8
0.50	2,046	1,261.0	125	1,755	1.2
0.75	3,069	1,261.3	131	2,711	1.5
1.00	4,092	1,261.6	136	3,668	1.8

The percentage of the PMF that will reach the top of the dam is 6 percent.

*Principal spillway crest elevation

**Top of dam elevation

```
A       OVERTOPPING ANALYSIS FOR HARDECKE LAKE DAM ( # 8 )
A       STATE ID NO. 30148  COUNTY NAME : GREENE
A       HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 80S3001
B    300                5
B1     5
J      1        9        1
J1   .05      .08      .10      .15      .20      .25      .50      .75      1.0
K      0        1                                  3        1
K1      INFLOW HYDROGRAPH COMPUTATION **
M      1        2     0.29             0.29        1                          1
P      0     26.7      102      120      130
T                                                              -1      -82             0.07
W2  0.21     0.13
X      0     -.1        2
K      1        2                          0        4        1
K1      RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE **
Y                                          1        1
Y1     1                                                     81       -1
Y4  1258   1259.0   1259.8   1260.5   1261.2   1262.0   1263.0   1264.0
Y5     0        4        8       57      171      300      775     1457
$S     0       43       81      106      291
$E  1238     1254     1258     1260     1270
$$  1258
$D1259.8
$L     0      200      357      480      620      620      620      620      620
$V1259.8   1259.9   1260.3   1260.4   1260.6   1261.0   1262.0   1263.0   1264.0
K     99
```

PMF RATIOS
INPUT DATA

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1	RATIO 2	RATIO 3	RATIO 4	RATIO 5	RATIO 6	RATIO 7	RATIO 8	RATIO 9
				0.05	0.08	0.10	0.15	0.20	0.25	0.50	0.75	1.00
HYDROGRAPH AT	1	0.29	1	205.	327.	409.	614.	818.	1023.	2046.	3069.	4092.
	(	0.75)	(	5.79)(	9.27)(	11.59)(	17.38)(	23.17)(	28.97)(	57.93)(	86.90)(	115.86)
ROUTED TO	2	0.29	1	8.	78.	188.	410.	588.	783.	1755.	2711.	3668.
	(	0.75)	(	0.21)(	2.21)(	5.33)(	11.62)(	16.64)(	22.16)(	49.70)(	76.76)(	103.88)

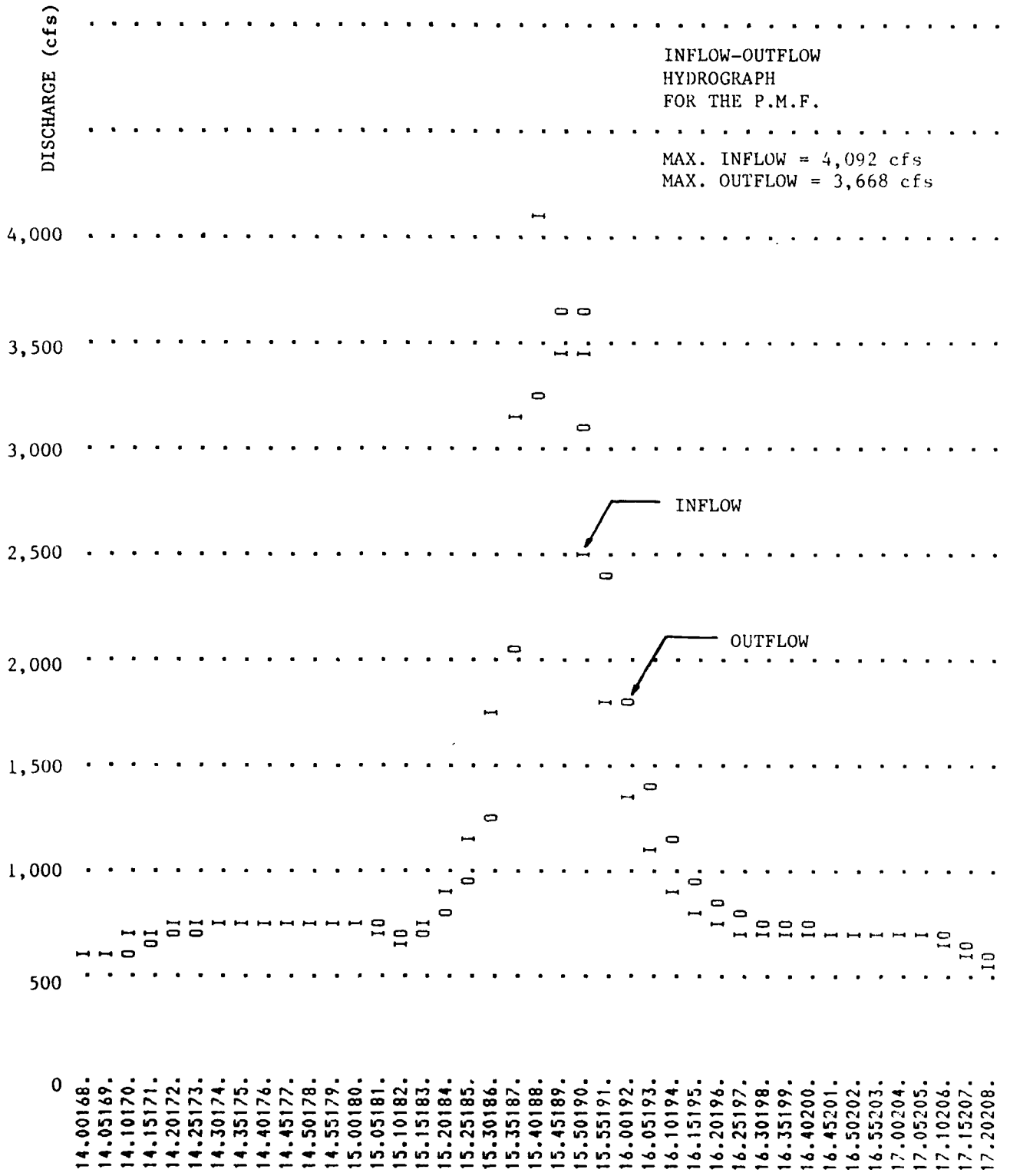
SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1258.00	1258.00	1259.80
STORAGE	81.	81.	103.
OUTFLOW	0.	0.	8.

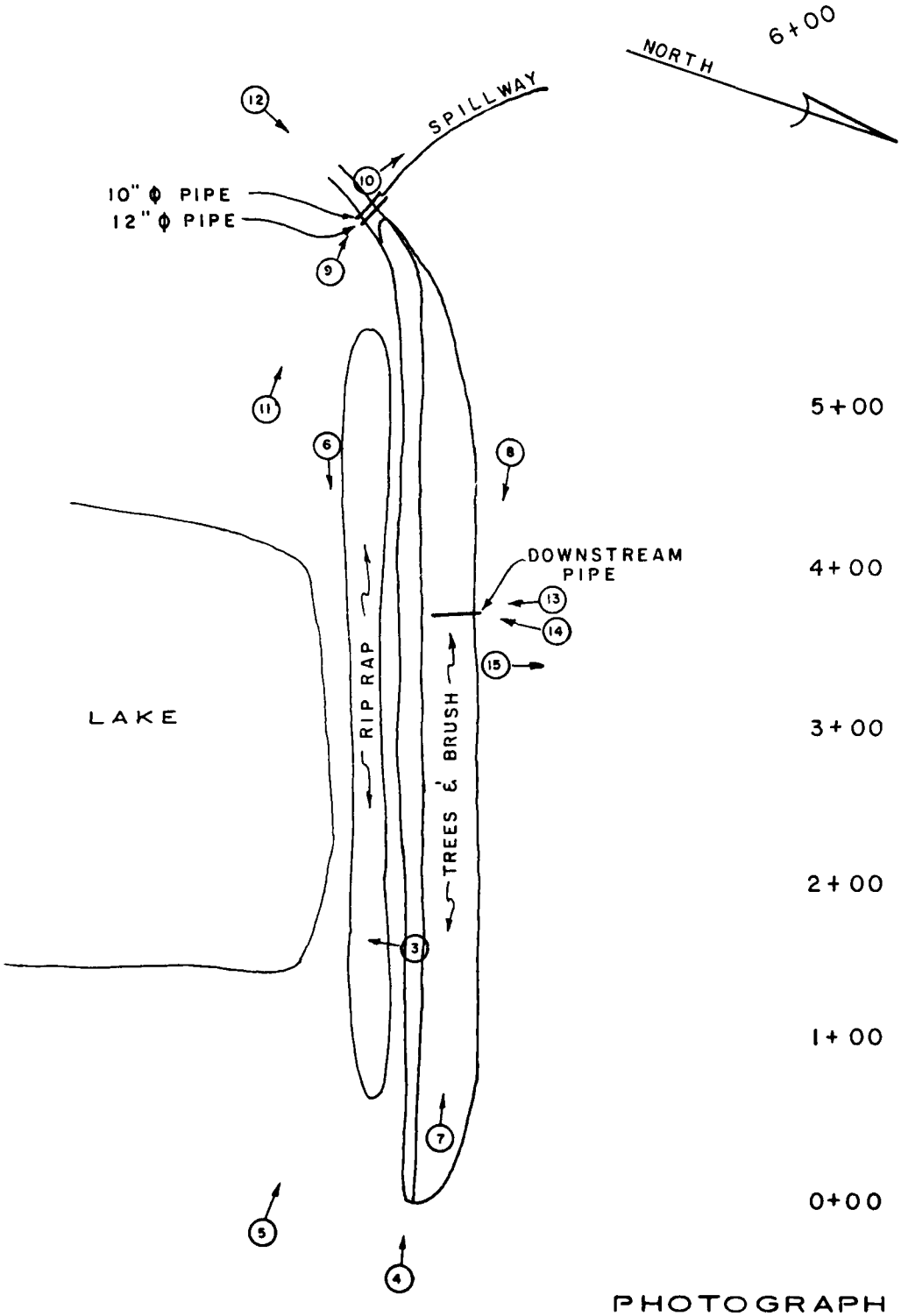
PMF RATIOS
OUTPUT DATA

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.05	1259.70	0.00	102.	8.	0.00	19.25	0.00
0.08	1260.04	0.24	107.	78.	6.08	16.17	0.00
0.10	1260.20	0.40	110.	188.	6.75	15.92	0.00
0.15	1260.42	0.62	114.	410.	10.08	15.83	0.00
0.20	1260.53	0.74	116.	588.	11.42	15.83	0.00
0.25	1260.64	0.84	118.	783.	12.00	15.75	0.00
0.50	1261.03	1.23	125.	1755.	14.08	15.75	0.00
0.75	1261.34	1.55	131.	2711.	15.58	15.75	0.00
1.00	1261.62	1.82	136.	3668.	16.42	15.75	0.00


DISCHARGE (cfs)
INFLOW-OUTFLOW
HYDROGRAPH
FOR THE P.M.F.
MAX. INFLOW = 4,092 cfs
MAX. OUTFLOW = 3,668 cfs
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
INFLOW
OUTFLOW
14.00168.
14.05169.
14.10170.
14.15171.
14.20172.
14.25173.
14.30174.
14.35175.
14.40176.
14.45177.
14.50178.
14.55179.
15.00180.
15.05181.
15.10182.
15.15183.
15.20184.
15.25185.
15.30186.
15.35187.
15.40188.
15.45189.
15.50190.
15.55191.
16.00192.
16.05193.
16.10194.
16.15195.
16.20196.
16.25197.
16.30198.
16.35199.
16.40200.
16.45201.
16.50202.
16.55203.
17.00204.
17.05205.
17.10206.
17.15207.
17.20208.
TIME (hrs)

APPENDIX D

Photographs



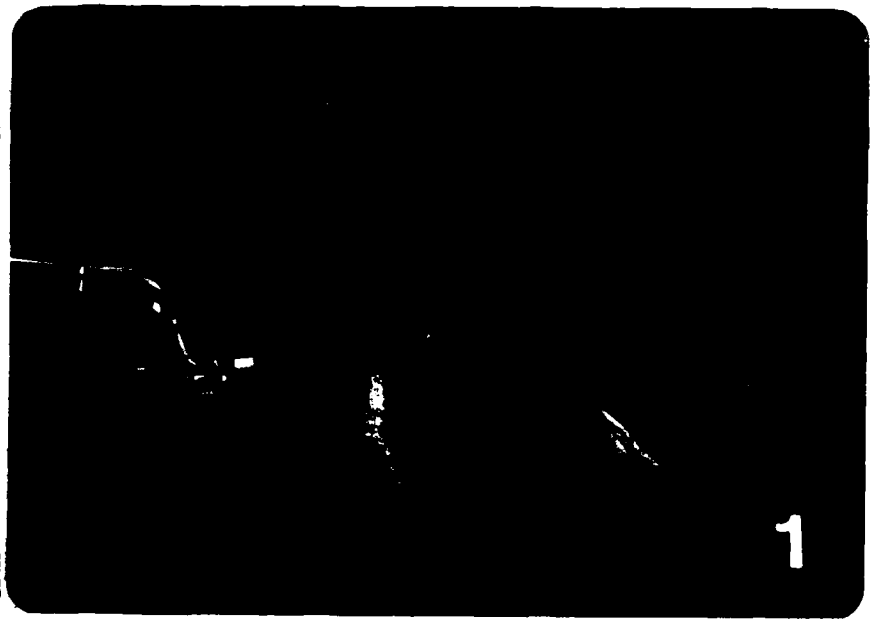
PHOTOGRAPH INDEX

HARDECKE LAKE DAM

MO. No. 30148

LIST OF PHOTOGRAPHS

PHOTO NO.	DESCRIPTION
1	Aerial View of Lake and Dam
2	Aerial View of Lake and Dam
3	View of Watershed and Reservoir (Looking South)
4	Crest of Dam (Looking West)
5	Upstream Face of Dam (Looking West)
6	Upstream Face of Dam (Looking East)
7	Downstream Face of Dam (Looking West)
8	Downstream Face of Dam (Looking East)
9	Spillway Pipes (Looking Northwest)
10	Downstream Spillway Channel (Looking Northwest)
11	Upstream Spillway Channel (Looking Northwest)
12	Spillway Channel at Centerline of Dam (Looking North)
13	Pipe Valve at Toe of Dam (Looking West)
14	Four Inch Pipe Valve at Toe of Dam (Looking South)
15	Downstream Channel (Looking North)
16	Cabin in Downstream Channel (Looking Southwest)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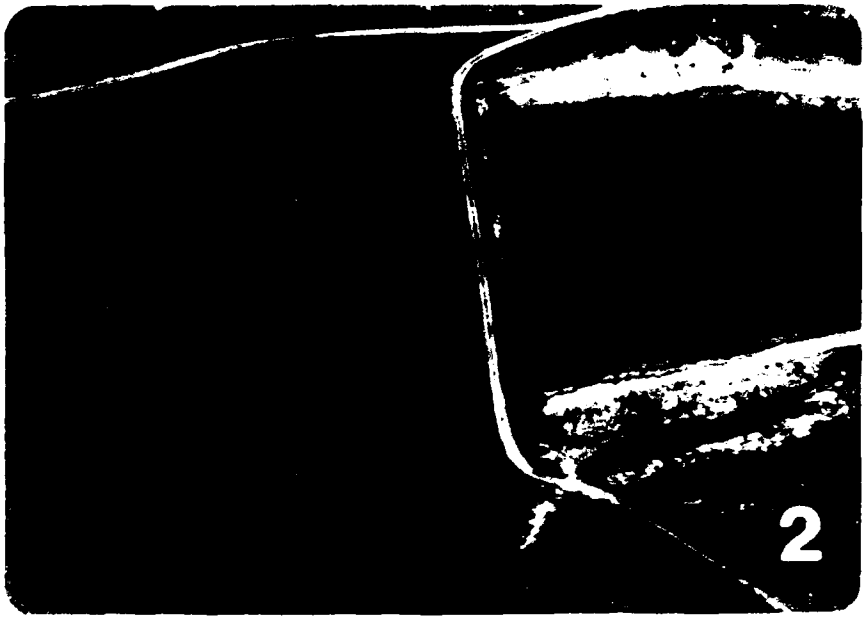
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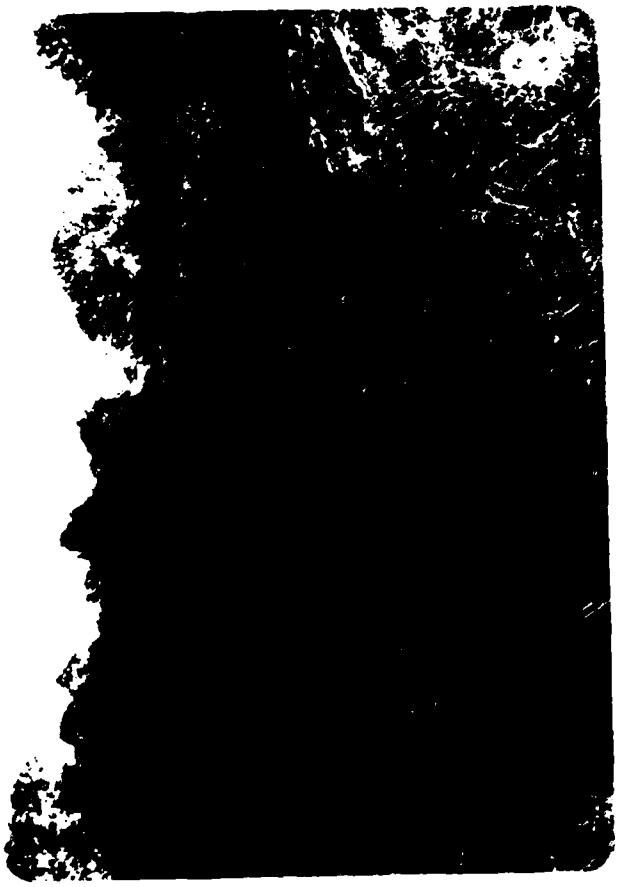


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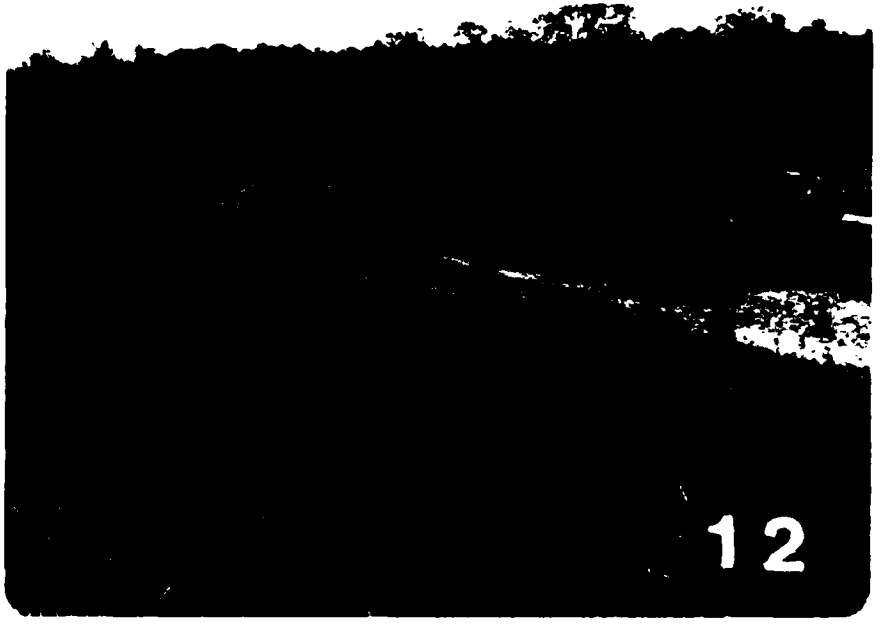
10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13


14


16